SOLAR ARRAY DEVELOPMENT FOR THE SURFACE OF MARS

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JPL's missions to Mars have revealed factors that have an adverse impact on the performance of Mars Surface Solar Arrays. These factors included a spectrum shift toward the red wavelengths, atmospheric scattering and absorption and an accumulation of Mars surface dust on the arrays. All of these factors will reduce the power generated from state of the art triple junction solar cells used by earth orbiting satellites. This paper will report the results of JPL supported work conducted by US solar array manufacturers to increase the performance of solar arrays for future Mars surface missions.
JPL awarded four vendors contracts to evaluate methods of improving power generation on the surface of Mars. These four contracts cover the redesign of the existing triple junction solar cell, modifying solar simulator output to match the Mars surface spectrum and techniques to control or remove dust from the surface of the arrays. The methodology and results of this evaluation will be presented in this paper.

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Review Abstract

JPL's missions to Mars have revealed factors that have an adverse impact on the performance of Mars Surface Solar Arrays. These factors included a solar spectrum shift toward the red wavelengths, atmospheric scattering and absorption and an accumulation of Mars surface dust on the arrays. All of these factors will reduce the power generated from state of the art triple junction solar cells used by earth orbiting satellites. Other factors that will improve power generation are the low radiation levels and temperature on the surface of Mars. This paper will report the results of JPL supported work conducted by US solar array manufacturers to increase the performance of solar arrays for future Mars surface missions.

JPL awarded four vendors contracts to evaluate methods of improving power generation on the surface of Mars. These four contracts cover the redesign of the existing triple junction solar cell, modifying solar simulator output to match the Mars surface spectrum and techniques to control or remove dust from the surface of the arrays.

One of the goals of these contracts was to enlist assistance from some of the best space qualified array manufacturers in the United States in order to eliminate the delay associated with technology transfer from R&D into production. The methodology and results of this evaluation will be presented in this paper.

The standard three junction space qualified solar cell power on the Mars surface will be diminish by about 11%, 7% due to the spectrum shifting toward the red and 4% due to the reduction in flux at Mars. All contractors come to the same conclusion on this fact. They also agree that 7% to 8% of that power can be recovered by optimizing the layer thickness and band gap to match current density for the Mars surface environment. This can be achieved by increasing the thickness and band gap of the top junction. The modifications proposed by the solar cell manufacturers are minimal and do not require a total requalification of the cell. These conclusions were based on a report by Dawson, Mardesich and Rapp; for the spectrum of energy on the surface of Mars convoluted with the measured external quantum efficiency of the modified triple junction solar cell. The solar cell contractors fabricated and tested Mars-spectrum-modified solar cells to demonstrate the effectiveness of the model.

Other Mars surface factors such as lower flux intensity resulting in lower operating temperature and optimum front grid design will improve the performance of the array. The lower flux intensity will allow the operating cell temperature to be 28°C or lower which will result in a 1% power increase per 7°C drop in cell temperature. This is much lower than the standard Earth orbiting satellite temperature of 90°C. A power gain of 0.5% can also be achieved with a new front grid design, taking advantage of the lower flux on Mars.

The accumulation of dust on the solar cells at the surface of Mars will significantly reduce the power output. AEC-ABLE conducted a survey to compare possible approaches to mitigate dust accumulation on the surface of solar arrays. As a result of the survey, AEC-ABLE selected and evaluated an electronic vibrating technique as the optimum approach to remove dust from the solar arrays on the Mars surface. They predict that a recovery of at least 90% of initial landing value can be achieved by this technique. Prototype designs have been developed and preliminary testing have been conducted demonstrating the effectiveness of the design.